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ABSTRACT

While educational researchers frequently collect data from a sample of individuals on a sample of variables, they sometimes collect data involving samples of: (1) subjects; (2) variables; and (3) occasions of measurement. A multistage procedure for analyzing such three-mode data is presented, focusing on effect sizes and graphic confidence intervals. The procedure was illustrated with a data set involving the perceptions of educational equity issues by medical school admissions officials. Admissions officials at 144 medical schools were asked to rate the extent of their agreement with 30 statements using a 5-point Likert scale; 91 subjects replied, yielding a response rate of 63.2%. A 91 x 30 x 4 matrix defined the three-mode data set. In the first phase, the referent mode was collapsed into the subject mode to yield a matrix that was subjected to principal components analysis. The first six components were extracted, and rotated to the varimax criterion. The second step involved retrieving the referent mode involving the four ethnic groups (Black students, Hispanic students, other minority students, and non-minority students). This was done by computing the 95% confidence interval about the mean factor score on each of the six components consisting of the ratings by the admissions officials of a single referent group. One figure illustrates the relative simplicity and graphic features of this approach; one table presents the item markers of the six components; and one appendix contains the matrix. (SLD)

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ALTERNATIVES TO THREE-MODE FACTOR ANALYSIS: A CASE STUDY WITH DATA EVALUATING PERCEIVED BARRIERS TO MEDICAL SCHOOL TRAINING

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ABSTRACT

The paper demonstrates a multi-stage procedure for analyzing "three-mode" data involving multiple (a) variables, (b) subjects, and (c) occasions of measurement. The relative simplicity and appealing graphic features of the approach are demonstrated. To make the discussion concrete, an actual data set involving the perceptions of educational equity issues by admissions officials from 91 medical schools is used to illustrate the approach.

Educational researchers frequently collect data from a sample of individuals on a sample of variables. In such cases variance among variables as replicated across people is typically the focus. However, sometimes researchers collect data involving samples of (a) subjects, (b) variables, as well as (c) occasions of measurement. Some methodologists characterize such data as being "three-mode" data, since three sources of variance simultaneously interact to influence responses (Cattell, 1966). Some sophisticated analytic methods (cf. Tucker, 1964, 1966, 1967) have been developed for use in such cases, but these methods are quite complicated.

The present paper explores the use of a simpler multi-stage analytic procedure being applied to three-mode data; the procedure focuses upon effect sizes and graphic confidence intervals. To make the discussion concrete, the procedure is illustrated using an actual data set involving responses by 91 subjects on 30 variables.

The Heuristic Data Set

The 30 variables involved perceptions of barriers to education in medical schools with respect to students' characteristics. The variables were developed using a delphi study, an approach that has proven useful in previous instrument development efforts (e.g., Lester & Thomson, 1989; Thomson & Ponder, 1979). The delphi process that ultimately produced the 30 items involved a national invitational conference; 34 professionals participated based on being nominated by one of the four sponsoring organizations (the Josiah Macy, Jr., Foundation, the Rockefeller Foundation, the Robert Wood Johnson Foundation, and the Baylor College of Medicine)

as individuals who had had significant leadership roles in promoting minority citizens' access to careers in the health professions. The delphi study resulting in the isolation of the 30 items is described in Baylor College of Medicine (1986).

For the purposes of the present study admissions officials at 144 medical schools in the United States and Canada were asked to rate extent of agreement with the 30 statements using 1 to 5 (5 = strong agreement) Likert scales. Admissions officials from 58 schools (40.3%) returned completed questionnaires after the first mailing, and an additional 33 officials (22.9%) completed questionnaires sent in a follow-up mailing to the admissions officials at the 86 schools not responding to the first mailing. Thus, representatives from 91 out of 144 medical schools completed questionnaires, and the response rate was 63.2%. This response rate was considered acceptable, especially given that the average response rate in survey research is typically about 33% (Kerlinger, 1986).

The 91 admissions officials rated extent of agreement that each of the 30 statements involved problems encountered by elementary and secondary educators working with each of four referent student populations: (a) Black students, (b) Hispanic students, (c) Other minority students, and (d) Nonminority students. Thus, a 91 by 30 by 4 matrix defined the three-mode data set in the present study.

An Hierarchical Alternative to Three-Mode Analysis

The focus of the analysis was on explaining variance in

perceptions of the four referent groups. The analysis was completed in two steps, as against implementing a three-mode procedure.

First, the referent mode was collapsed into the subject mode such that a 364 row (91 subjects times four referents) by 30 (variables) column data matrix resulted. The correlation matrix for this data matrix was subjected to a conventional R-technique (Cattell, 1966; Sells, 1963) principal components analysis. The eigenvalues prior to rotation (Thompson, 1989) for fourth through the tenth components were 1.54, 1.45, 1.44, 1.16, 1.07, 1.00, and 0.90, respectively.

A decision was taken to extract the first six components. The components were rotated to the varimax criterion. Table 1 presents the two items most highly correlated with each of the six components. The factors were labelled: (a) Environmental Influences, (b) Misperceptions of Reality, (c) Inadequate Feedback, (d) Subject Deficiencies, (e) System Openness, and (f) Fraternal Support. Conventional, standardized, least squares factor scores were computed (Thompson, 1983) on each factor for each row of the data matrix, resulting 364 rows of six Z scores.

INSERT TABLE 1 ABOUT HERE.

The second step of the analysis involved retrieving the referent mode involving the four ethnic groups. This was done by computing 95% confidence interval about the mean factor score on each of the six components consisting of the ratings by the 91 admissions officials of a single referent group. This resulted in

24 (6 factors x 4 referents) factor score confidence intervals. These confidence intervals are presented graphically in Figure 1.

INSERT FIGURE 1 ABOUT HERE.

Confidence intervals that did not overlap portray means that differed to a statistically significant degree. Statistically significant and noteworthy differences occurred on factors I and III. On Factor I, "Environmental Influences," Blacks and Hispanics were perceived to experience generally comparable levels of denied equal access to educational oportunity. Other minorities also were perceived as being disadvantaged relative to Nonminorities, though not as severely as were Blacks and Hispanics. All three minority groups were perceived to experience denial of equal access to performance feedback, relative to Nonminority students, as reflected in results on Factor III, "Inadequate Feedback."

Summary

The analysis presented in Figure 1 illustrates the relative simplicity and appealing graphic features of this approach to analyzing three-mode data. A reader can readily discern the results of the entire analysis, summarized in a single graphic. Such results are even more useful when there is greater variability in the width of the confidence intervals about different means. Thus, this procedure is recommended as one useful approach that can be utilized to analyze three-mode data.

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Table 1
Selected Item Markers of Each of the Six Components

Factor I: Environmental Influences

.751 27 Poor student performance in mathematics and science may be due to variations in cognitive and non-cognitive development attributable to cultural or ethnic background that are not addressed through current instructional programs.

.720 12 Deficiencies in language and reading skills represent significant problems that influence student performance in mathematics and science.

Factor II: Misperceptions of Reality

.754 28 Student exposure to community needs that may encourage interest in careers in mathematics and science is insufficient.

.554 17 A general emphasis on performance in sports and atheletics has negatively influenced student interest and performance in more traditional areas of study such as science and mathematics.

Factor III: Inadequate Feedback

.697 7 Barriers exist between guidance counselors and students which can result in student reliance on advice from peer-group members.

.629 6 Assessments of student performance that do not accurately reflect the level of achievement or potential of the student represent a frequent problem.

Factor IV: Subject Deficienies

.716 3 Students in all grades lack problem-solving, reasoning, and evaluation skills which are considered by many as a requisite for success in mathematics and science courses.

.593 4 Students often self-assess their academic strengths and weaknesses unrealistically and many times fail to realize when they are having academic difficulties.

Factor V: System Openness

.697 30 Special activities, such as academic decathalons, are effective enrichment activities that motivate students to devote additional effort to mathematics and science studies.

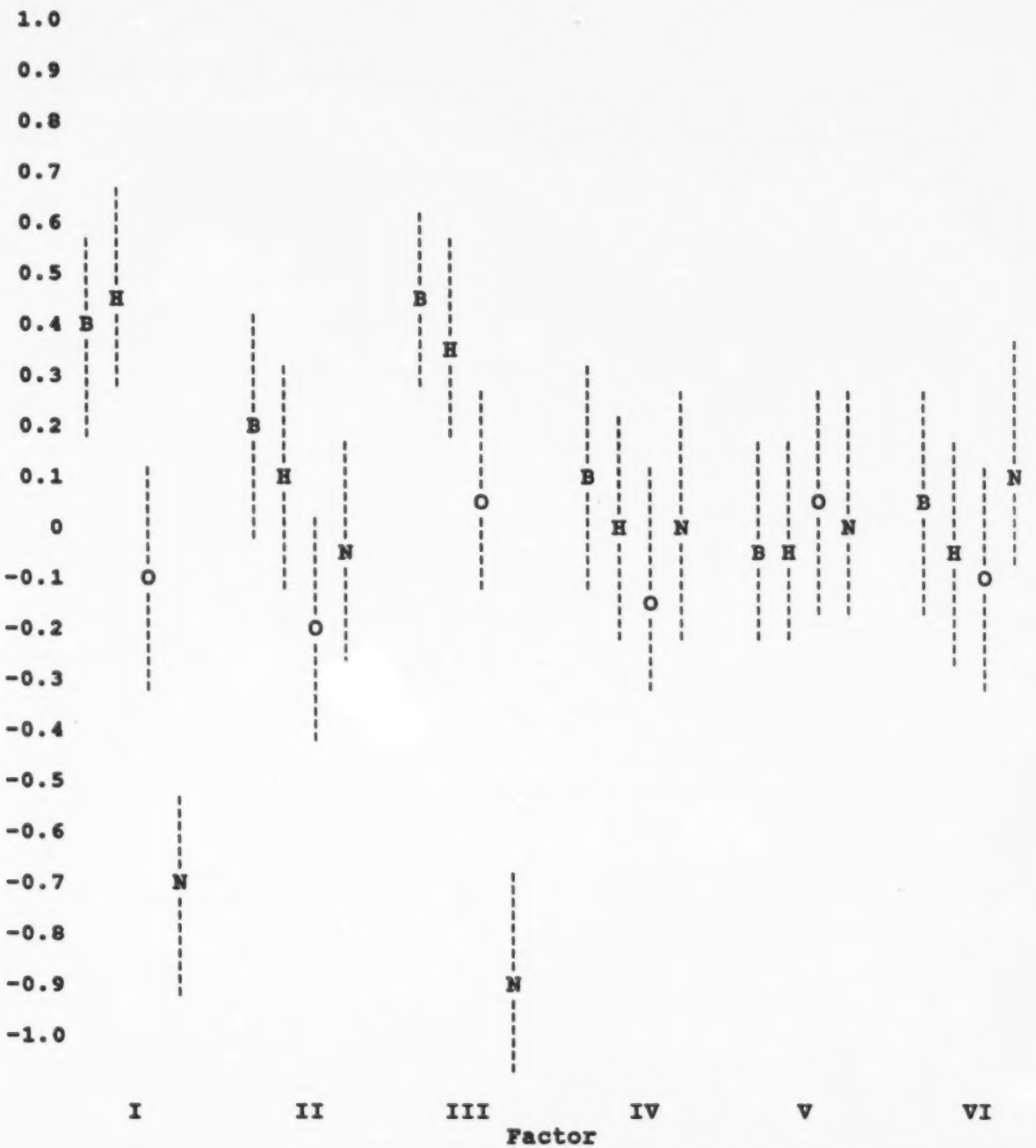
.630 29 Master teachers from varying ethnic backgrounds would be effective in enhancing student performance in mathematics and science.

Factor VI: Fraternal Support

.705 14 There appears to be an attitude among many students that their ethnic background will enhance the probability that they will be accepted into a college or a professional school.

.625 16 Special interest groups and clubs at schools (e.g., Science Club, Computer Club, Mathematics Society, etc.) are useful in generating and maintaining student interest in mathematics and science.

Figure 1
95% Confidence Intervals About Means



Note. "B" = Black; "H" = Hispanic; "O" = Other minority; "N" = Nonminority.

Appendix A:
Varimax-Rotated Factor Pattern/Structure Matrix

Item	I	II	III	IV	V	VI
Q27	.751	-.030	-.083	.113	.207	.086
Q12	.720	.296	.188	-.036	.094	-.010
Q11	.715	-.003	.282	.154	-.023	.071
Q9	.671	.287	.030	.210	-.082	.107
Q22	.554	.526	.063	-.045	-.049	-.052
Q2	.534	.239	.234	.116	-.068	-.077
Q10	.520	.130	.348	.068	.070	-.026
Q25	.472	-.019	.201	.306	.190	-.093
Q1	.464	.153	.379	.418	-.206	-.039
Q28	.156	.754	.110	.032	-.013	.037
Q17	.286	.554	.263	.038	.208	.027
Q5	.122	.548	.140	.524	.129	-.089
Q13	.493	.543	.041	.266	.073	.036
Q20	-.042	.481	.075	-.208	-.084	.249
Q15	.156	.466	-.027	.110	.138	-.355
Q7	.238	.047	.697	.163	.156	-.031
Q6	.394	.048	.629	.094	.147	-.033
Q18	-.044	.252	.610	.186	-.150	-.070
Q8	.255	-.018	.539	-.336	.187	.324
Q19	.187	.319	.409	.198	.146	-.014
Q3	.256	.024	.208	.716	-.039	.055
Q4	.202	.236	.094	.593	.298	.068
Q21	.042	-.137	.070	.503	-.109	.286
Q30	-.047	.038	.048	-.114	.697	.139
Q29	.073	.232	.245	.001	.630	.250
Q26	.236	-.151	-.108	.307	.575	-.205
Q24	.042	.420	.339	.094	.428	-.076
Q14	.146	.087	-.106	.180	.011	.705
Q16	-.137	-.065	-.032	.018	.282	.625
Q23	.244	.255	.318	.300	-.005	.391